them) the upper fore extremity of their falces is furnished with strong spines. In the present spider, whose nest is made in channels already existing, the crevices and rugulosities of the bark of trees, there is no need of such spines; and their absence is thus accounted for. An interesting speculation suggests itself here, *i. e.* whether the present spider is prior or subsequent in point of genealogical relationship to the trap-door spiders that form a nest in the earth, and are specially furnished with spines on the falces to excavate the holes for it. It is, it seems to me, most conceivable that spiders should first take advantage of sites already suited for their habitations, and that subsequently the species fitted for forming their own sites should be gradually developed.

EXPLANATION OF PLATE X.

Fig. 1. *a*, spider, enlarged; *b*, ditto, in profile, without legs or palpi; *c*, eyes, from above and behind; *d*, underside of cephalothorax, showing maxillæ, labium, sternum, and basal joints of the legs; *e*, tarsus of one of the second pair of legs; *f*, natural length of spider.

Fig. 2. A, nest in piece of bark; B, another nest in groove of a piece of wood; C, lid of nest detached, showing the inner side.

XLIII.—*On the true Nature of the so-called* "Bathybius," *and its alleged Function in the Nutrition of the Protozoa.* By G. C. Wallich, M.D.

At no previous period in the history of deep-sea research had a more boldly conceived, but, as I venture to think, more untenable doctrine, been offered for acceptance by the scientific public, than when the alleged discovery of this extraordinary Protozoon was formally announced by Prof. Huxley.

In 1868 this distinguished biologist published an elaborate paper "On some Organisms from great depths in the North Atlantic," in which he expressed the opinion that certain masses of protoplasmic matter, found in specimens of deep-sea mud which had been submitted to him for examination in 1857, constitute a new phase of living being, to which he gave the name of "*Bathybius*." In referring to this subject in their first "Preliminary Report on Deep-sea Dredgings," published just afterwards in the 'Proceedings of the Royal Society,' viz. in Dec. 1868, Drs. Carpenter and Wyville Thomson say that "the examination which Prof. Huxley has been good enough to make of the peculiarly viscid mud brought up in our last dredging at the depth of 650 fathoms,

has afforded him a remarkable confirmation of the conclusion he announced at the recent Meeting of the British Association, that the coccoliths and coccospheres are imbedded in a living expanse of protoplasmic substance, to which they bear the same relation as the spicules of Sponges or of Radiolaria do to the soft parts of those animals. Thus it would seem that the whole mass of this mud is penetrated by a living organism of a type even lower, because less definite, than that of Sponges and Rhizopods." And they add that, to whichever of the two great kingdoms in nature we refer it, "*there seems adequate reason for regarding this* Bathybius *as one of the chief instruments whereby the solid material of the calcareous mud which it pervades is separated from its solution in the ocean-waters.*" To this description Dr. Carpenter adds, in a footnote, that "*the discovery of this indefinite plasmodium covering a wide area of the existing sea-bottom should afford a remarkable confirmation, to such* (*at least*) *as still think confirmation necessary, of the doctrine of the organic origin of the serpentine limestone of the Laurentian formation. For if* Bathybius, *like the testaceous Rhizopods, could form for itself a shelly envelope, that envelope would closely resemble* Eozoon. *Further, as Prof. Huxley has* proved *the existence of* Bathybius *through a great range, not merely of depth but of temperature, I cannot but think it probable that it has existed continuously in the deep seas of all geological epochs*"*.

At a Meeting of the Royal Geographical Society on the 29th Nov. 1870†, Prof. Huxley himself still further signalized his reputed discovery in these words:—"*The* Bathybius *formed a living scum or film on the sea-bed, extending over thousands upon thousands of square miles; evidence of its existence had been found throughout the whole North and South Atlantic, and wherever the Indian Ocean had been surveyed, so that it probably forms one continuous scum of living matter girding the whole surface of the earth. This opinion had been confirmed in all its essential details by Prof. Haeckel, who had published an admirable account of specimens obtained by him*"‡.

It is almost superfluous to point out that emphatic and authoritative statements such as these, published in the journals and, to this extent, under the august prestige of two of the

* "Preliminary Report on Deep-sea Dredgings," by Dr. Carpenter and Dr. Wyville Thomson (Proceedings of the Royal Society, Dec. 17, 1868, pp. 190, 191).

† 'Proceedings of the Royal Geographical Society,' March 23, 1871, vol. xv. no. 1, p. 38.

‡ The italics in the above paragraphs are mine.—G. C. W.

first Scientific Societies of Great Britain, were well calculated to be accepted—and, as a matter of fact, are well known to have been accepted—by nearly all the leading biologists of the day, both in this country and abroad; whilst they necessarily served to block out entirely, and, as events have proved, to throw discredit upon any attempt to controvert them. How far the circumstances warranted such results, the facts about to be narrated will doubtless attest.

Prof. Huxley's paper announcing the discovery of "*Bathybius*" appeared in 'The Quarterly Journal of Microscopical Science' in 1868*. In that paper Prof. Huxley says, "I conceive that the granule heaps and the gelatinous matter in which they are imbedded, represent masses of protoplasm. Take away the cysts which characterize the Radiolaria, and a dead *Sphærozoum* would very nearly resemble one of the masses of this deep-sea 'Urschleim,' which must, I think, be regarded as a new form of those simple animated beings which have recently been so well described by Haeckel in his 'Monographie der Moneren.' ... From the manner in which the youngest *Discolithi* and *Cyatholithi*† are found imbedded among the granules, from the resemblance of the youngest forms of *Discolithi* and the smallest corpuscles of *Cyatholithus* to the granules, and from the absence of any evident means of maintaining an independent existence in either, I am led to believe that they are *not* independent organisms, but that they stand in the same relation to the protoplasm of *Bathybius* as the spicula of sponges, or of the Radiolaria, do to the soft parts of those animals" ‡.

Here, then, we are furnished with a description, meagre indeed, but nevertheless the sole description which, so far as I am aware, Prof. Huxley has published of *Bathybius*. It will be seen from it that the varieties of "*coccoliths*" spoken of under the name of "*discoliths*" and "*cyatholiths*" were

* "On some Organisms from Great Depths in the Atlantic," by Prof. Huxley, F.R.S. (Quarterly Journal of Microscopical Science, Oct. 1868, no. xxxii. p. 210).

† Names given by Prof. Huxley to varieties of "*coccoliths*."

‡ Prof Huxley having stated, in confirmation of the accuracy of his observations, that he had "employed higher powers of the microscope when he examined the North-Atlantic mud, than subsequent observers seem to have employed, his great help having been an excellent $\frac{1}{12}$ by Ross, which easily gives a magnifying-power of 1200 diameters and renders obvious many details hardly appreciable with the $\frac{1}{6}$ objective he used in 1857," I may be permitted to mention that all my work has been done with Ross's lenses, ranging up to $\frac{1}{12}$, and a Hartnack's immersion-lens, No. 10, specially made for me. These lenses cannot be surpassed in defining-power. As most microscopists know, perfect definition is a quality of much greater consequence than simple amplification.

regarded by him as integral and essential portions of its structure. It followed, therefore, if the "*coccoliths*" could be shown *to bear no physiological relation whatever* to the viscid matter described as protoplasm, but to be purely accidental accompaniments of the matter composing the mud generally, the fabric of *Bathybius* must fall to the ground.

It therefore becomes absolutely necessary to recapitulate in this place, not only the history of the "*coccoliths*" but of the *coccospheres*, which were first discovered by me in 1860, and were shown, on evidence which can no longer admit of a shadow of doubt, to constitute the complete organism of which the "*coccoliths*," whether "*cyatholiths*" or "*discoliths*," are nothing more than the *disjecta membra*. Partly on these grounds, but chiefly because my own personal observation had satisfied me that "*Bathybius*" is the *effete product, instead of being the source* of any of the vital forces which are already in operation at the sea-bed, I ventured, with confidence in the justice of my cause, though with but too well-founded misgiving regarding the consequences to myself of daring to gainsay the conclusions of so deservedly high an authority as Prof. Huxley, to show that the alleged existence of *Bathybius* was wholly *illusory*.

I may here state that the substance of the present paper was written six months ago, and that within the past six weeks Prof. Huxley has himself virtually acknowledged the error into which he had been betrayed, in a few lines appended to an extract from a letter addressed to him by Dr. Wyville Thomson, dated Yeddo, June 9, 1875, which was published in 'Nature' of August 19 of the present year. The following is the text of Prof. Huxley's statement:—"Prof. Wyville Thomson further informs me that the best efforts of the 'Challenger's' staff have failed to discover *Bathybius* in a fresh state, and that it is seriously suspected that the thing to which I gave that name is *little more than sulphate of lime*, precipitated in a flocculent state from the sea-water by the strong alcohol in which the specimens of the deep-sea soundings which I examined were preserved. The strange thing is that this inorganic precipitate is scarcely to be distinguished from precipitated albumen, and it resembles, perhaps even more closely, the proligerous pellicle on the surface of a putrescent infusion (except *in the absence of all moving* particles), colouring irregularly, but very fully, with carmine, running into patches with defined edges, and in every way comporting itself like an organic thing. Prof. Thomson speaks very guardedly, and does not consider the fate of *Bathybius* to be as yet absolutely decided. But since I am mainly responsible for the mistake, if it be one, of

introducing this singular substance into the list of living things, I think I err on the right side in attaching even greater weight than he does to the view which he suggests."

With reference to this remarkable withdrawal of opinion and of previously assumed facts, it only remains for me to say that, rejoiced though I am to find my views on the subject so fully substantiated, the persistent mode in which my published observations have for a long series of years been ignored, and the fact that Prof. Huxley to the last moment ascribes the rectification of his error altogether to Prof. Wyville Thomson, who has *throughout* his writings upon the "*coccoliths*"-and-*coccosphere* question, as on numerous other equally important points, failed to accord to my observations the recognition to which his not unfrequent appropriation of their substance, and even of the very words in which they were couched, proves me to have been entitled, renders it more than ever indispensable that I should place in the clearest light the methods by which these ends have been gained, quite as much in the interest of scientific truth as in vindication of my own claims*.

In the appendix to Captain Dayman's Report on 'Deep-sea Soundings in the North Atlantic Ocean,' taken in 1857, published in 1858†, Prof. Huxley, who was then intrusted with the examination of the materials, observes that he "found in almost all these deposits a multitude of very curious rounded bodies, to all appearance consisting of several concentric layers surrounding a minute clear centre, and looking, at first sight, somewhat like single cells of the plant *Protococcus*; as these bodies, however, are rapidly and completely

* The contradictory nature of Prof. Thomson's statements will appear from the following passages. In his work, 'The Depths of the Sea,' published in 1873, p. 413, he says, with a singular disregard of accuracy in his quotation of my opinion, that "the 'coccoliths' are sometimes found aggregated on the surface of small transparent membranous balls; and these, which seemed *at first* to have something to do with the production of the 'coccoliths,' Dr. Wallich has called coccospheres;" whereas, in a communication dated from the 'Challenger,' and published in 'The Proceedings of the Royal Society' for Nov. 1874 (p. 38), he unhesitatingly renounces the opinion just cited, and informs us that "*his* observations have placed it beyond a doubt that the 'coccoliths' are the separated elements of a peculiar calcareous armature which covers certain spherical bodies (the coccospheres of Dr. Wallich)." Thus while he repudiated, in the first instance, my conclusion, supported as it was by direct and detailed evidence, he now claims the merit of the discovery, without having offered a particle of evidence on the subject!

† 'Deep-sea Soundings in the North Atlantic,' made in H.M.S. 'Cyclops' by Lieut.-Commander Dayman, in June and July 1857: London, 1858, p. 64.

decomposed by dilute acids, *they cannot be organic*, and I will, for convenience sake, simply call them *coccoliths*." No further description was given of these bodies at that period.

In my preliminary sketch of the results obtained by me on board the 'Bulldog,' in the North Atlantic, in 1860, entitled, "Notes on the Presence of Animal Life at vast Depths in the Ocean"*, written at sea, and published in November of that year within a few days of my return from the expedition, I made the following statement:—"In almost every sample of *Globigerina*-ooze these bodies (the '*coccoliths*') have been detected by me. But I have invariably found associated with them, in greater or less quantity, certain large cell-like masses the average diameter of which is about $\frac{1}{1000}$th of an inch, *on the immediate surface of which minute bodies were regularly ranged at intervals, so closely resembling the free 'coccoliths' in look and structure as to leave little doubt that the latter are given off from the former.* The cell-like central portion, together with the '*coccolith*'-like bodies, are imbedded in a gelatinous-looking capsule, the exact nature of which it was out of my power to determine accurately at sea. The association of the largest number of both these kinds of bodies in the soundings in which the *Globigerinæ* were in greatest quantity and in the purest condition, is worthy of notice, and is almost suggestive of their being the larval condition of these organisms. The smallest *Globigerina*-shell met with by me in this material measured $\frac{1}{600}$th of an inch in diameter, and contained but two chambers, the size of the free '*coccoliths*' being $\frac{1}{3000}$th of an inch in diameter, or five times smaller. In some specimens the 'minute clear centre' was most distinctly divided into two portions. Much additional investigation will, however, be necessary before any reliable deductions can be arrived at as to the nature and functions of these very remarkable structures"†.

Again, in the 'Annals and Magazine of Natural History' for July 1861, in a paper "On some novel phases of Organic Life at great Depths in the Sea," I observed that, "in the deepest soundings taken during the recent expedition to the

* 'Notes on the Presence of Animal Life at vast Depths of the Ocean' (Taylor & Francis, London, 1860). This pamphlet was originally printed for presentation only to scientific societies and scientific men, both here and abroad. Almost immediately afterwards, by permission of the Hydrographer to the Admiralty, a new edition was printed and sold in the usual fashion, reviews of it appearing in various scientific journals of the time.

† *Op. cit.* p. 14.

North Atlantic, I detected these very curious bodies (the '*coccoliths*' of Prof. Huxley) in great numbers, occurring not only in the free state noticed by Prof. Huxley, but as adjuncts to minute spherical cells, *upon the outer surface of which they were adherent in such a manner as to leave no doubt of that being their normal position.* Whilst alluding to their occurrence in my published 'Notes' [above referred to] I ventured a surmise as to their being a larval condition of some of the Foraminifera :—first, in consequence of their being invariably present in greatest quantity in such of the deep-sea deposits as were most prolific of these organisms; secondly, because in one or two instances coccoliths had been met with by me adherent to Foraminiferous shells in such a manner as to render it highly improbable that they could have attained their position by accident; and, lastly, because the spherical cells to which reference has been made, when entirely freed from their adherent coccoliths, presented no discernible points of difference, save as regards somewhat inferior dimensions, from the minute and nearly hyaline solitary cells of the earliest stage of the *Globigerinæ*."

"On reference to the annexed woodcut it will be seen that the composite bodies to which I allude, and to which I propose to give the name of coccospheres, are minute spherical cells having a defined limitary wall, and that upon their outer surface the coccoliths of Prof. Huxley are arranged at nearly regular intervals. The cells, when crushed, are seen to contain a homogeneous, gelatinous, and almost colourless matter, exhibiting no visible trace of organization,

No. 1. *Coccosphere* with its superimposed "*coccoliths*." No. 2. *Coccosphere-cell* without its "*coccoliths*."

and, in all probability, consisting of sarcode. The wall of the cell may be distinctly seen under a high power; but, from the minuteness of the entire structure, I had found it impossible to do more than attest its existence. Accordingly there is nothing visible to show whether the wall is formed of one or more than one layer. Cells are sometimes met with in a fractured condition; but I have never observed a collapsed specimen, or flattened-out fragment, such as would frequently occur were the *basis* of the wall formed of any thing more yielding than *calcareous matter*. In like manner, I have hitherto failed to detect markings or apertures in the limitary wall of the coccosphere. The solitary cells vary in diameter from $\frac{1}{1600}$ to $\frac{1}{1250}$ of an inch, when seen separately. Forming part of a series, as in the specimen of *Textularia*

presently to be described, some cells, however, attain a much larger size"*.

"The coccoliths (to which term I would restrict the minute bodies described by Prof. Huxley) are of oblong shape, concave on their internal aspect, namely that on which they are attached to the surface of the coccosphere-cells, and convex externally; in short, they are spoon-shaped, only with a much less marked convexity and concavity. In some specimens a single aperture, only, occurs at the central portion. In others the aperture appears to be double; or, rather, there are two perforations, placed side by side, in the direction of the long axis of the body, and separated from each other by an extremely delicate transverse band; whilst the external marginal surface, which thus constitutes a quoit-like but oblong ring round the central perforated portion, is striated in a radiate manner. When the two perforations are present the little mass closely resembles a miniature plate of *Synapta*. The coccoliths, like the spheres upon which they rest, are transparent and devoid of colour. Their mode of attachment is not distinguishable, owing to their extreme minuteness. They appear, however, to be simply placed in contact with the surface of the coccosphere-wall, and to be retained in position by the delicate gelatinous layer in which the entire organism is invested. We may thus account for the seeming facility with which the coccoliths are detached, and the vast numbers of free coccoliths which crowd many of the deposits"†.

Apart, therefore, from the primary question whether "*Bathybius*" does or does not possess the characters attributed to it—characters which, if existent, must have wholly revolutionized our views regarding both the biological and geological relations of the sea-bed—it must be obvious that the true relation of the "coccoliths" to the coccospheres, and the equally significant facts (pointed out by me *some years* previously), first, that the coccospheres are normally *free-floating organisms*, inhabiting the surface-waters of the open ocean ‡, *where there exists no protoplasmic matrix for them to be imbedded in*,

* In a collection of microscopic slides illustrating the nature of the North-Atlantic deposits, which was presented by me to the Microscopical Society in 1867, there are numerous examples both of Textularian and Rotalian shells, the outside of the chambers of which are studded with coccoliths as here described.

† "On some novel Phases of Organic Life at great Depths in the Sea," by G. C. Wallich, M.D. &c. (Annals and Magazine of Natural History, July 1861, p. 52).

‡ See paper "On the Structure and Affinities of the Polycystina," by G. C. Wallich, M.D. &c. (Quarterly Journal of Microscopical Science for July 1865, footnote).

and subsiding to the bottom in a disintegrated condition only after death—secondly, that coccospheres are to be met with in abundance in dredgings along the coasts of the British Channel*—and, lastly, that coccoliths occur also in abundance in the post-tertiary fossil-earths of America†,—assume an importance that would not, under other circumstances, have pertained to them.

It has been shown that, whereas Prof. Huxley, in his original report, declared that the coccoliths "*cannot be organic*," I proved them to be organic; whereas he doubted their being the *disjecta membra* of the coccospheres, I proved them to be so; and whereas he alleged that they normally, as "coccoliths," "discoliths," or "cyatholiths," constitute part and parcel of the living thing to which he gave the name of *Bathybius*, I distinctly proved that the "coccoliths" have no physiological connexion with the viscid matter in which they are imbedded at the bottom of the sea, but are detached and normal appendages of coccospheres which have lived in the superficial waters of the ocean, and subsided to the bottom only after death.

As already stated, Prof. Huxley's announcement of *Bathybius* appeared in the 'Quarterly Journal of Microscopical Science' for October 1868. In the following number of the same journal (Jan. 1, 1869), in a paper upon "The Vital Functions of the Deep-sea Protozoa," I entered very fully into a refutation of Prof. Huxley's alleged discovery of *Bathybius*, quoting, much more *in extenso* than I should be justified in doing here, the whole of Prof. Huxley's published observations on the subject up to that date, and also Dr. Carpenter's views regarding the organization and mode of nutrition of the Foraminifera, with many points of which my own observations were at direct variance. To that paper I beg those who take sufficient interest in the question to refer. At present I must confine myself to giving the following extracts as bearing most directly upon *Bathybius*‡.

* See paper "On *Amœba villosa* and other indigenous Rhizopods," by G. C. Wallich, M.D. &c. (Annals and Magazine of Natural History, June 1863, footnote p. 445); and also a paper "On the Vital Functions of the Deep-Sea Protozoa," by same author (Monthly Microscopical Journal, Jan. 1, 1869).

† "On the Structur eand Affinities of the Polycystina," by same author ('Quarterly Journal of Microscopical Science' for July 1865, footnote).

‡ "On the Vital Functions of the Deep-Sea Protozoa," by G. C. Wallich, M.D. &c. (Monthly Microscopical Journal, Jan. 1, 1869, pp. 38 & 39). Of the contents of this paper not the slightest notice has been taken, either by Prof. Huxley, Dr. Carpenter, or Dr. Wyville Thomson. I am quite content to submit to the verdict of every impartial critic, whether

"Regarding the expediency of attempting to establish a new grade of animal life possessing characters as yet so obscure and indefinite as that on which Prof. Huxley has conferred the name *Bathybius*, I beg with great deference to express my doubts:—in the first place, because I can see no reason to deny to the structure called a coccosphere, quite as independent an individuality as is observable in *Thalassicolla* or *Collosphæra*; in the second, because the very name *Bathybius*, if its substance is supposed to have any immediate connexion with the presence, the development, or the nutrition of the lower forms of animal life which inhabit the ocean, is in direct antagonism to the occurrence of surface-living forms, for the nutrition and development of which a separate provision would have to be made; and, in the third and last place, because it appears to me that analogy and the bulk of direct evidence is in favour of the supposition that this widely distributed protoplasmic matter is the *product*, rather than the *source*, of the vital forces which are already in operation at the sea-bed."

"It is true that the evidence afforded by *Eozoön* may be cited in support of *Bathybius*. But we must not lose sight of the fact that of the animal of *Eozoön* we know as yet extremely little beyond its having been recognized by Professor Carpenter as distinctly of a Rhizopodous type*, and certainly not enough to warrant the inference that its body-substance was less highly differentiated than that of an ordinary Foraminifer, or that each individual, within certain limits, may not have been distinct, though inhabiting a structure as vast, in its general proportions, as the coral reef."

"But, apart from the insufficiency of the evidence on which the existence of *Bathybius* rests, it appears to me that, even were it to be accepted as conclusive, we should not approach a single step nearer to the solution of the problem it may be

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this fact, viewed in connexion with the recently demonstrated and *admitted* validity of my disproof of the existence of "*Bathybius*," is at all consistent with the established rules of scientific inquiry and discussion.

* In the same number of 'The Monthly Microscopical Journal,' at pp. 60, 61, the following statement is given on the authority of Dr. Carpenter:—"Dr. Carpenter then referred to the protoplasmic network which Prof. Huxley had termed *Bathybius*, and which, as Dr. Wallich had stated, was limited to the warm area, and not found where the arctic currents prevailed." This statement (for which I do not hold Dr. Carpenter responsible) is wholly incorrect, and in direct antagonism to the opinions I have throughout entertained and expressed regarding "*Bathybius*." No remark has, at any time, been made by me with reference to the distribution of the so-called "*Bathybius*." The assertion here conveyed must evidently, therefore, have originated in some misconception of the writer's.

desired to elucidate—that is, the mode in which the earliest existing form of animal life manifests itself, and, in the absence of the conditions without which vegetable life of the most primitive kind cannot be present, obtains nutriment, and becomes, in its turn, food for organisms of a somewhat more complex structure."

It would appear that the analysis of deep-sea mud upon which Prof. Huxley based his original conclusions with regard to *Bathybius* was made with material which had been preserved "in spirits" since the year 1857, when it was obtained by Capt. Dayman—that is to say, during a period of nearly eleven years. But, according to Dr. Carpenter's report in the Royal Society's 'Proceedings' for December 1868, these conclusions received "*remarkable confirmation*" on Prof. Huxley's examination of mud recently obtained in a dredging, made at a depth of 650 fathoms by Dr. Carpenter and Prof. Wyville Thomson in the autumn of that year, to the westward of the Faröe Islands, "*the coccoliths and coccospheres being imbedded* in a *living* expanse of protoplasmic matter, to which they bear the same relation as the spicules of sponges or of Radiolariæ do to the soft parts of those animals. . . . It may be that the *Bathybius* (which bears a very striking resemblance to the Rhizopod-like *mycelium* of the Myxogastric Fungi) has so far the attributes of a vegetable that it is able to elaborate organic compounds out of the materials supplied by the medium in which it lives, *and thus to provide sustenance for the animals imbedded* in its midst"*.

The drift of these remarks is obvious; and it was with a view to show their fallacy that I wrote as follows (*loc. cit. suprà*, pp. 39, 40, 41), towards the conclusion of the paper "On the Vital Functions of the Deep-Sea Protozoa," from which the last of my quotations was an extract:—

"Like most theories which admit of being directed towards the solution of the mystery in which the boundary between the animal and vegetable kingdoms has hitherto been shrouded, the idea of a widely pervading protoplasmic layer (drawn, on the one side, from the assumed analogy of *Eozoön*, and, on the other, from a substance of the exact relations of which we have also still much to learn, namely *Æthalium*) would merely thrust before us one difficulty instead of another. For, even if we allow the existence of *Bathybius* as an independent organism, it would still become necessary to invest it with an exceptional specific property—namely, of being able to convert inorganic elements into its own body-substance.

* "Preliminary Report," by Dr. Carpenter and Prof. Wyville Thomson ('Proceedings of the Royal Society,' Dec. 17, 1868, p. 191).

"This is, no doubt, in direct opposition to preconceived notions of the distinction existing between the Protophyta and Protozoa; but I cannot help thinking that, on a closer scrutiny of the grounds upon which the distinction is based, it will be found to have its foundation in words rather than in established facts, and that the vital attribute now claimed for the lowest Protozoon is, in reality, as compatible with reason and observed phenomena as some of the other attributes which have been unhesitatingly acceded both to the Protozoa and the Protophyta"*.

"According to Dr. Carpenter, 'There is reason to consider the shell-substance of the Foraminifera as an *excretion* from the protoplasmic mass of which the body itself is composed, just as the cellulose wall of the vegetable cell, which may be consolidated by carbonate of lime (as in Corallines) or by silex (as in Diatoms), is an excretion from the contained endochrome'†. But inasmuch as the term 'excretion' involves vitality, or, to put the case in other words, since the shell-substance *would not be excreted were the animal dead*, it is obvious that the process is, in point of fact, one of *secretion*, dependent, in the first instance, on the creature's power of eliminating carbonic acid and lime from the waters it inhabits, and, in the second, of reproducing these materials in the shape of its shell-substance. Unless we admit this explanation, it is difficult to see how we can escape the more serious dilemma of having to assume that solid atoms of carbonate of lime are merely passed mechanically through the animal's body, going in at one side in the shape of solid atoms, and coming out at the other in the shape of specially conformed shell-tissue. And, be it observed, the same objection holds good as regards the *process* by which the "consolidation" of the cellulose wall —by carbonate of lime or silex, as the case may be—takes place in the Protophyte; for it is only so long as we consent to be hoodwinked by a definition which cannot, under any

* It shall be shown in a future paper that my views on the question of nutrition have within the past six months been absolutely verified by the independent observations of Messrs. W. H. Dallenger and J. Drysdale, 'On the Life-history of the Monads.' The entire subject of the nutrition of the Protozoa will then be fully entered into. Meanwhile I may be permitted to observe that the very important researches of Dr. Hooker and Mr. Darwin "On Carnivorous Plants" have demonstrated the fallacy of the old established preconceived notions respecting the immutability of the boundary-line which has been so vainly and arrogantly drawn between the animal and the plant, based, as it was, almost wholly on the mode of nutrition.

† "On the Systematic Arrangement of the Rhizopoda," Natural History Review, no. 4, October 1861, p. 472.

circumstances, be accepted as universally applicable, that any doubts can arise as to there being a gradual and not a sudden transition from the confines of one great division of the organic world to the other. But, for reasons already assigned, this transition from the vegetable side is *not, and probably cannot be*, completed under those conditions which prevail below certain fixed limits of depth in the ocean."

"If we admit this much as regards the process of shell-deposit, the ground is at once cleared for us; and, *mutatis mutandis*, the elimination from the surrounding waters of the elements entering into the composition of body-substance, and their conversion into this substance by a special vital faculty inherent in the protoplasmic mass itself, become at once as easy of comprehension as any purely vital act can be."

"Lastly, if *Bathybius* be assumed to constitute the nutritive substance of *Globigerina*, it follows that, where the largest and purest deposits of that Foraminifer present themselves, there ought to be the greatest supply of the nutritive protoplasm. But, as already shown, this is the reverse of what we find to be the case, inasmuch as amongst the purest Globigerine deposits, where these organisms amount to 80 or 85 per cent. of the entire mass, hardly a trace of gelatinous matter is observable"*.

But it remains for me to show still more definitely what are Prof. Wyville Thomson's opinions concerning *Bathybius* and the nutrition of the Protozoa generally. In the preface to his work 'The Depths of the Sea,' published three years later, namely in 1873 (Preface, p. viii), Prof. Thomson tells us that "the domain of biology is his own particular province." What he has to say on any such important subject as the attributes of *Bathybius* ought therefore to command respectful attention; for the same reason it is indispensable to quote his *ipsissima verba* on the subject.

"Prominent among these special groups we find the first and simplest of the Invertebrate subkingdoms, the Protozoa, represented by three of its classes, the Monera, the Rhizopoda, and the Sponges. . . . The German naturalists of the new school, in their enthusiastic adoption of the Darwinian theory of evolution, naturally welcome in these 'Moners' the essential attribute of the 'Urschleim;' an *infinite capacity for improvement in every conceivable direction*; and to more prosaic physiologists they are of the deepest interest, as presenting

* "On the Vital Functions of the Deep-Sea Protozoa," by G. C. Wallich, M.D. &c. ('Monthly Microscopical Journal,' January 1, 1869, pp. 39, 40, 41).

the essential phenomena of life, nutrition and irritability, existing apparently simply as the properties of a homogeneous chemical compound and independent of organization"*. . . .

"In this dredging" [Prof. Thomson here alludes to the 650-fathom sounding taken off the Faröes to which Dr. Carpenter, as already shown at p. 332, has referred], "as in most others in the bed of the Atlantic, there was evidence of a considerable quantity of soft gelatinous matter, enough to give a slight viscosity to the mud of *the surface*-layer. If the mud be shaken with weak spirit of wine, white flakes separate, like coagulated mucus; and if a little of the mud in which this viscid condition is most marked be placed in a drop of sea-water under the microscope, we can usually see, after a time, an irregular network of matter, resembling white of egg, distinguishable by its maintaining its outline and not mixing with the water. This network may be seen gradually altering its form, and entangled granules and foreign bodies change their relative positions. The gelatinous matter therefore is capable of a certain amount of movement; and *there can be no doubt that it manifests the phenomena of a very simple form of life*"†. . . . . "The circumstance which gives its special interest to *Bathybius* is its enormous extent; whether it is continuous in a vast sheet, or broken up into circumscribed individual patches, it appears to extend over a large part of the bed of the ocean"‡.

Referring to the "coccoliths" found imbedded in the substance of *Bathybius*, Prof. Thomson says, "they are very probably taken into it with a purpose, for the sake of the vegetable matter they may contain, and which may afford food for the animal jelly. . . . Living *upon* and among the *Bathybius* we find a multitude of other Protozoa; and we as yet know very little of the life-history of these groups. There can be no doubt that, when their development has been fully traced, many of them will be found to be di- or poly-morphic, and that, when we are acquainted with their mode of multiplication, we shall meet with many cases of pleo-morphism and wide differences between the *organs* and products involved in propagation and in reproduction"§.

Prof. Thomson sums up his singularly infelicitous and, so far as what has gone before is concerned, singularly inconsistent statement, as follows:—"I feel by no means satisfied that *Bathybius* is the permanent form of any distinct living

* The Depths of the Sea. By Prof. W. Thomson, LL.D., F.R.S., &c. London: 1873, pp. 408, 409.

† Depths of the Sea, p. 410. ‡ Ibid. pp. 411, 412.

§ Ibid. pp. 414, 415.

being. It has seemed to me that different samples have been different in appearance and consistence; and although there is nothing at all improbable in the abundance of a very simple shell-less Moner at the bottom of the sea, I think it not impossible that a great deal of the '*Bathybius*' (that is to say, the diffused formless protoplasm which we find at great depths) may be a kind of mycelium, a formless condition connected either with the growth or the multiplication, or with the decay, of many different things"! *

In the words of Prof. Karl Möbius:—"To suppose that the simplest organisms originate at the bottom of the sea by primitive generation has something very seductive in it. It suits wonderfully well with old cosmogonies and *new theories*. But we shall never succeed in demonstrating its occurrence there; and even if we could methodically produce primitive generation in our laboratories, we could assert nothing further than that perhaps such primitive generation may take place at the bottom of the sea"†.

This is perfectly true, and serves to explain why advanced biologists should have been so eager to hail the alleged "discovery" of an "independent," "living," "indefinite plasmodium, extending over enormous areas of the sea-bed," as rapturously as Archimedes would have hailed the much-coveted plot of ground from which he pledged himself to move the world. Messrs. Carpenter and Thomson‡ allege that "there is no difficulty in accounting for the alimentation of the higher animal types with such an unlimited supply of food as is afforded by the *Globigerinæ* and the *Sponges* in the midst of which they live, and on which many of them are known to feed." But they add, with laudable frankness, "*Given the Protozoa, every thing else is explicable. But the question returns,—On what do these Protozoa live?*" Here was the true Archimedean difficulty revived. Prof. Thomson cuts the Gordian knot after a new fashion when he says §, "It is *therefore* [?] quite intelligible that a world of animals should live in these dark abysses; *but it is a necessary condition that they should chiefly belong to a class capable of being supported by absorption through the surface of matter in solution, deve-*

* Depths of the Sea, p. 415.

† "Whence comes the Nourishment for the Animals of Deep Seas?" by Prof. Karl Möbius. Translated by W. S. Dallas, F.L.S., from a separate copy of the paper sent by the author to Dr. J. E. Gray, F.R.S. ('Annals and Magazine of Natural History,' September 1871, p. 203.)

‡ "On the Scientific Exploration of the Deep Sea," by Messrs. Carpenter, Jeffreys, and Thomson, 'Proceedings of the Royal Society,' Nov. 18, 1869, p. 477.

§ *Loc. cit.* p. 478.

loping but little heat, and incurring a very small amount of waste by any manifestation of vital activity." He then dogmatically affirms, without furnishing any thing whatever in the shape of rational proof, that "*it is the distinctive character of the Protozoa that they have no special organs of nutrition, but that they absorb water through the whole surface of their jelly-like bodies.*"

I venture to say that, in all the annals of scientific research, such startling hypotheses succeeded by such facile verification, such unguarded assumptions put forth with the authority of facts, such oracular solutions of most important questions as that involved, first, in the production of substantiatory evidence with regard to *Bathybius*, and, secondly, in the prospective compromise, equally capable of negative or affirmative interpretation, which is apparent in the paragraph in which Dr. Wyville Thomson sums up by saying he "*does not think* Bathybius *is the permanent form of any distinct living being*," have never been equalled.

Though I do not presume to offer myself as an apologist for Prof. Huxley, I fully appreciate the extreme difficulties under which he worked when analyzing material unquestionably altered in its most important characters by the admixture of alcoholic preservative solutions. I can attest, from personal and long-continued experience, that it is simply impossible to arrive at a correct knowledge of the characters of the recent and unadulterated material from material that has been thus preserved. The fact is that there is as marked a distinction between the aspect of pure fresh sponge-protoplasm, for example, seen instantly on its arrival at the surface, and its aspect a very brief period afterwards, as there is between that of the living Foraminifera or Polycystina of the open ocean immediately after capture, and after they have been consigned to some preservative solution. In addition to other important changes produced in the protoplasm of the Protozoa, both marine and freshwater, by being long kept or preserved in such preservative solutions as alcohol when calcareous matter exists in solution, molecular changes take place, the normally homogeneous protoplasm then frequently being converted into minute globular masses, which, when seen under the microscope, resemble sago grains in miniature, and may readily be mistaken for molecular granules of the organism within or upon which they occur. I can produce specimens of Polycystina, and, to a certain extent, of Foraminifera, the rich and varied brilliancy of colour in which has been retained for years, in some cases, even when mounted in balsam; but there all identity in the appearance of the soft parts ends: and

so it must be with any protoplasmic matter. On the other hand, every one conversant with the behaviour of viscid fluids such as albumen, when *squeezed* between the glass slide and cover for the purpose of microscopic examination, will no doubt recollect how constantly, partly through capillary attraction and partly through the faint elasticity resident in such substances, movements, which *simulate* vital ones, may be observed. But Prof. Thomson has distinctly asserted that in the examples cited above by him there "*can be no doubt that the gelatinous matter manifested the phenomena of a very simple form of life*"*.

I submit that the case has been widely different as regards Drs. Carpenter and Wyville Thomson's opportunities. They undoubtedly enjoyed opportunities of the first order for arriving at the truth on this question. For, whilst Prof. Huxley's original observations with respect to "*Bathybius*" were based on the microscopical analysis of materials which had been bottled up for upwards of ten years in alcohol, and the whole bulk of which might have been estimated in *grains*, the "remarkable confirmation" which the reputed discovery was alleged to have received almost immediately afterwards was based on a *dredging* made by Drs. Carpenter and Thomson at a depth of 650 fathoms; in describing which they triumphantly state that "Our Dredge" brought up 2½ cwt. of mud at a haul †—a quantity which, in less accomplished hands, and with far less perfectly organized means than Drs. Carpenter and Thomson commanded, might have sufficed to elicit the truth from the sea-bed. It may fairly be assumed that Drs. Carpenter and Thomson examined some of this mud as soon as their dredge arrived at the surface; for we are told that "*the mud was actually alive*; it stuck together in lumps as if there were white of egg mixed with it; and the glairy mass *proved* under the microscope to be *living sarcode*. Prof. Huxley regards this as a distinct creature, and calls it '*Bathybius*'"‡. With reference to this statement, it seems quite impossible to understand how, in the perfectly fresh material which Prof. Wyville Thomson so graphically describes, this "*glairy* mucus, *proved* to be *living sarcode*," and which was said above to be *the* veritable "*Bathybius*," can really be "*little more than sulphate of lime, precipitated* in a *flocculent* [!] state *from the sea-water by strong alcohol*"!

* Depths of the Sea, p. 410.

† "Preliminary Report," by Drs. Carpenter and Thomson (Proc. Roy. Soc., Dec. 17, 1868, pp. 175 & 190).

‡ Prof. Thomson, "On the Depths of the Sea," Annals and Magazine of Natural History, Aug. 1869, p. 121.

Surely the dredge never rendered more sorry service to science than when it was made to yield up this "remarkable confirmation."

It is with a sense of amazement, therefore, that I have in vain searched the numerous writings of Drs. Carpenter and Thomson for any thing in the shape of satisfactory, or even generally consistent, evidence to justify so many hasty assumptions and so many mere assertions put forth as *facts* under cover of expressions alleging that they are "well known," or "there cannot be the least doubt," &c. &c. It is obvious that the entire significance of *Bathybius* rested on the truth or fallacy of the supposition that it *lives*, and is "*an independent*" and "*indefinite*" *organism*. Were further proof needed to show that Drs. Carpenter and Thomson recognized this fact, it is to be found in their observation that "*the indefinite protoplasmic expansion named* Bathybius *is amongst the most important results obtained by the sounding-apparatus*"*. They might with truth have added by the "*Dredge*."

In one expression of Prof. Wyville Thomson's, when referring to the advanced school of German naturalists, I heartily concur—namely, "in the infinite capacity of the '*Urschleim*' for improvement *in every conceivable direction*."

Regarding the true origin and functions of the protoplasmic, *non-living* substance which is found associated with certain deep-sea deposits, I shall do my best to give an account in a future communication.

XLIV.—*Description of a supposed new* Actinura *from the Dafla Hills.* By Major H. H. Godwin-Austen, F.R.G.S., F.Z.S., &c., Deputy Superintendent, Topographical Survey of India.

Among the birds collected by me on the Expedition into the Dafla hills, Assam, last winter, one of the most interesting forms is the *Actinura* I now describe. As might be expected, its nearest ally is *A. nipalensis*, Hodgs., the coloration above being very similar on the back and tail, but with less rufous barring. The crest, however, is quite different; and in this respect the species approaches *A. Waldeni* from the Naga hills, on the south of the Brahmaputra valley, only that the crest is far fuller. The general blotchy streakiness of the throat

* In a communication to the Royal Society dated June 17, 1869. See Proceedings.